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Schneider

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(54) **USERNAME BASED KEY EXCHANGE**

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CPC ***H04L 9/0844*** (2013.01); ***H04L 9/3271*** (2013.01)

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CPC ... H04L 9/3271; H04L 9/0863; H04L 9/3226; H04L 9/0844; H04L 2209/80; H04L 63/08; H04W 12/06
USPC 713/171
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,491,752	A	2/1996	Kaufman et al.	
5,774,552	A *	6/1998	Grimmer	713/156
6,049,612	A	4/2000	Fielder et al.	
6,073,234	A	6/2000	Kigo et al.	
6,085,320	A	7/2000	Kaliski, Jr.	
6,189,096	B1	2/2001	Haverty	
6,243,811	B1 *	6/2001	Patel	713/167
6,249,867	B1 *	6/2001	Patel	H04L 9/0841 380/255
6,401,206	B1	6/2002	Khan et al.	
6,792,424	B1	9/2004	Burns et al.	
6,883,717	B1	4/2005	Kelley et al.	
7,031,468	B2	4/2006	Hoffstein et al.	
7,073,061	B2 *	7/2006	Asano et al.	713/168
7,096,494	B1 *	8/2006	Chen	G06Q 20/04 380/259
7,194,765	B2	3/2007	Blom	
7,231,521	B2 *	6/2007	Buddhikot et al.	713/171
7,242,766	B1	7/2007	Lyle	
7,363,651	B2	4/2008	De Jong et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO2005002131 1/2005

OTHER PUBLICATIONS

Biryukov, Alex et al., "Cryptanalysis of the Alleged SecurID Hash Function (extended version)" Lecture Notes in Computer Science, Springer-Verlag, 2003, 18 pages.

(Continued)

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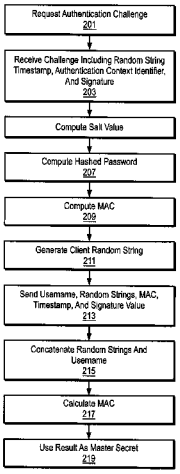
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

A method and apparatus for an system and process for sharing a secret over an unsecured channel in conjunction with an authentication system. A client computes a message authentication code based on a hashed password value and a first random string received from the server. The client sends a response to the server that includes authentication data including a second random string. Both the client and server concatenate the first random string, second random string and username. Theses values are processed to generate as a shared master secret to further generate shared secrets or keys to establish a secured communication channel between the client and server. The secured communication can be based on stateless messaging where the decryption key associated with the message is identified by the message authentication code, which is placed within the message.

19 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,673,142	B2	3/2010	Jeffries et al.	
7,945,776	B1	5/2011	Atzmony et al.	
8,156,333	B2	4/2012	Schneider	
8,225,093	B2	7/2012	Fok et al.	
8,352,738	B2	1/2013	Parno et al.	
8,660,268	B2	2/2014	Schneider	
2002/0056040	A1*	5/2002	Simms	713/171
2002/0146005	A1	10/2002	Gallant et al.	
2003/0014646	A1*	1/2003	Buddhikot et al.	713/184
2003/0093671	A1	5/2003	Owlett	
2003/0105964	A1	6/2003	Brainard et al.	
2003/0233546	A1	12/2003	Blom	
2003/0236803	A1	12/2003	Williams	
2004/0223619	A1	11/2004	Jablon	
2005/0081036	A1*	4/2005	Hsu	713/171
2006/0021036	A1*	1/2006	Chang et al.	726/22
2006/0041759	A1	2/2006	Kaliski et al.	
2006/0235700	A1	10/2006	Wong et al.	
2007/0005963	A1	1/2007	Eldar et al.	
2007/0101152	A1	5/2007	Mercredi et al.	
2007/0169181	A1	7/2007	Roskind	
2007/0226784	A1	9/2007	Ueda et al.	
2008/0034216	A1	2/2008	Law	
2008/0077979	A1	3/2008	Jeffries et al.	
2008/0155112	A1	6/2008	Ma	
2008/0301435	A1	12/2008	Simon	
2009/0193511	A1	7/2009	Noe et al.	
2009/0271462	A1	10/2009	Schneider	
2009/0287929	A1*	11/2009	Kolesnikov et al.	713/171
2009/0288143	A1	11/2009	Stebila et al.	
2009/0300364	A1	12/2009	Schneider	
2010/0131756	A1	5/2010	Schneider	
2011/0131415	A1	6/2011	Schneider	

OTHER PUBLICATIONS

Office Action for U.S. Appl. No. 12/111,893 mailed Apr. 14, 2011.
Office Action for U.S. Appl. No. 12/111,893 mailed Oct. 11, 2011.
Office Action for U.S. Appl. No. 12/156,278, mailed Sep. 26, 2011.
Notice of Allowance for U.S. Appl. No. 12/156,278, mailed Nov. 23, 2011.
Office Action for U.S. Appl. No. 12/324,108, mailed Nov. 16, 2011.
Belare, Mihir, et al., "Keying Hash Functions for Message Authentication", ,http://cseweb.uscd.edu/~mihir/papers/kmd5.pdf . . . Published Jun. 1996.
Franks, J., et al., "RFC 2617 HTTP Authentication: Basic and Digest Access Authentication", IETF (Jun. 1999).
Oath Reference Architecture Release 2.0, Initiative for Open Authentication (2007).
Xiang, Fei et al. "A New Pseudo-Random Number Generator with Application in RSA", IEEE 2008.
Office Action for U.S. Appl. No. 12/111,893 mailed Oct. 31, 2012.
Office Action for U.S. Appl. No. 12/111,893 mailed Apr. 18, 2013.
Notice of Allowance for U.S. Appl. No. 12/111,893 mailed Oct. 3, 2013.
Office Action for U.S. Appl. No. 12/324,108, mailed Feb. 29, 2012.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed Sep. 4, 2012.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed Jan. 22, 2013.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed May 9, 2013.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed Nov. 18, 2013.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed Apr. 9, 2014.
USPTO, Advisory Action for U.S. Appl. No. 12/111,893, mailed Dec. 16, 2011.
USPTO, Advisory Action for U.S. Appl. No. 12/324,108, mailed May 8, 2012.
USPTO, Notice of Allowance for U.S. Appl. No. 12/324,108, mailed Apr. 7, 2015.
USPTO; Office Action for U.S. Appl. No. 12/628,109, mailed Dec. 24, 2014.
USPTO, Notice of Allowance for U.S. Appl. No. 12/628,109, mailed Jul. 15, 2015.

* cited by examiner

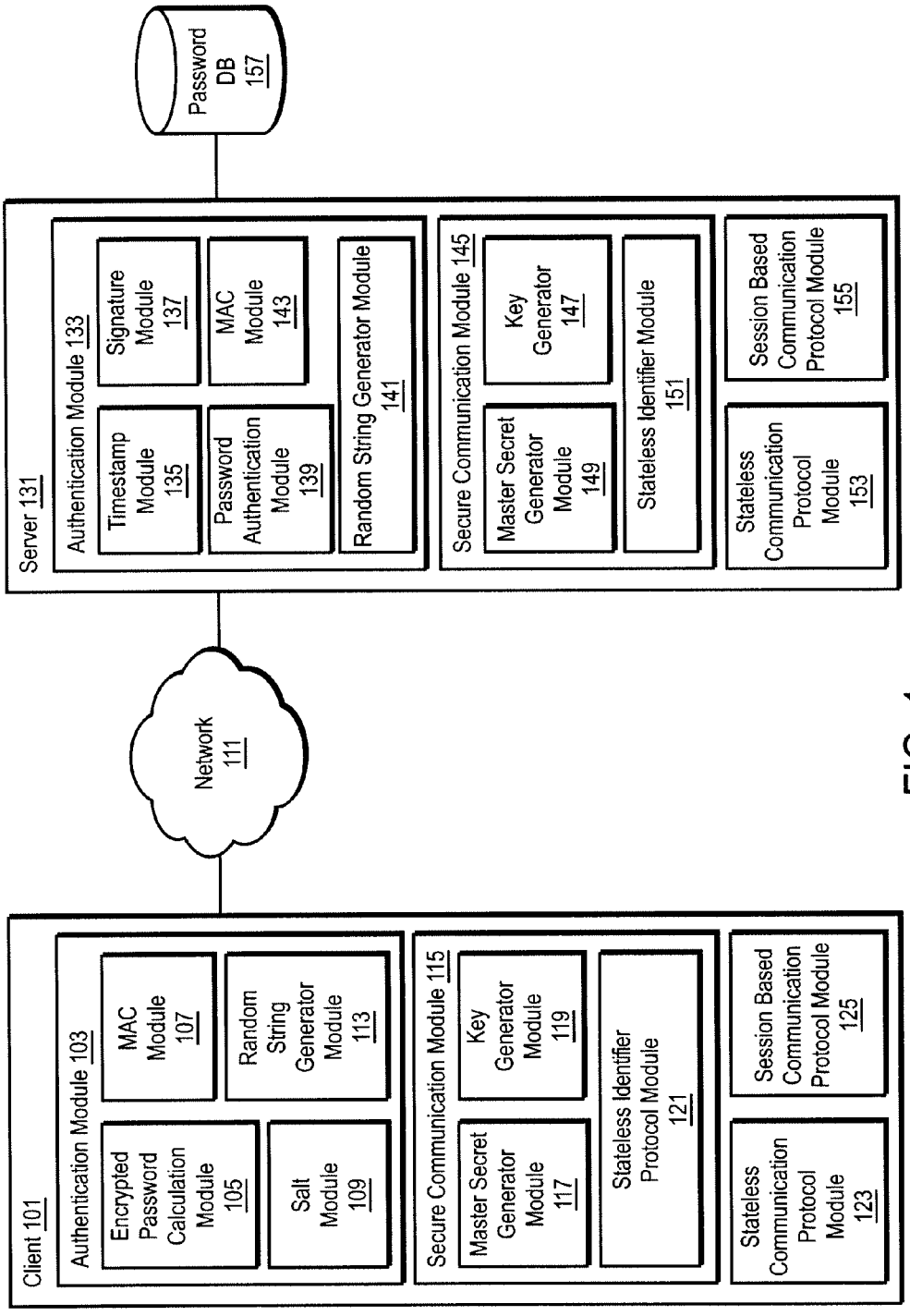

Client 101
Authentication Module 103
Encrypted Password Calculation Module 105
MAC Module 107
Salt Module 109
Random String Generator Module 113
Secure Communication Module 115
Master Secret Generator Module 117
Key Generator Module 119
Stateless Identifier Protocol Module 121
Stateless Communication Protocol Module 123
Session Based Communication Protocol Module 125
Network 111
Server 131
Authentication Module 133
Timestamp Module 135
Signature Module 137
Password Authentication Module 139
MAC Module 143
Random String Generator Module 141
Secure Communication Module 145
Master Secret Generator Module 149
Key Generator 147
Stateless Identifier Module 151
Stateless Communication Protocol Module 153
Session Based Communication Protocol Module 155
Password DB 157

FIG. 1

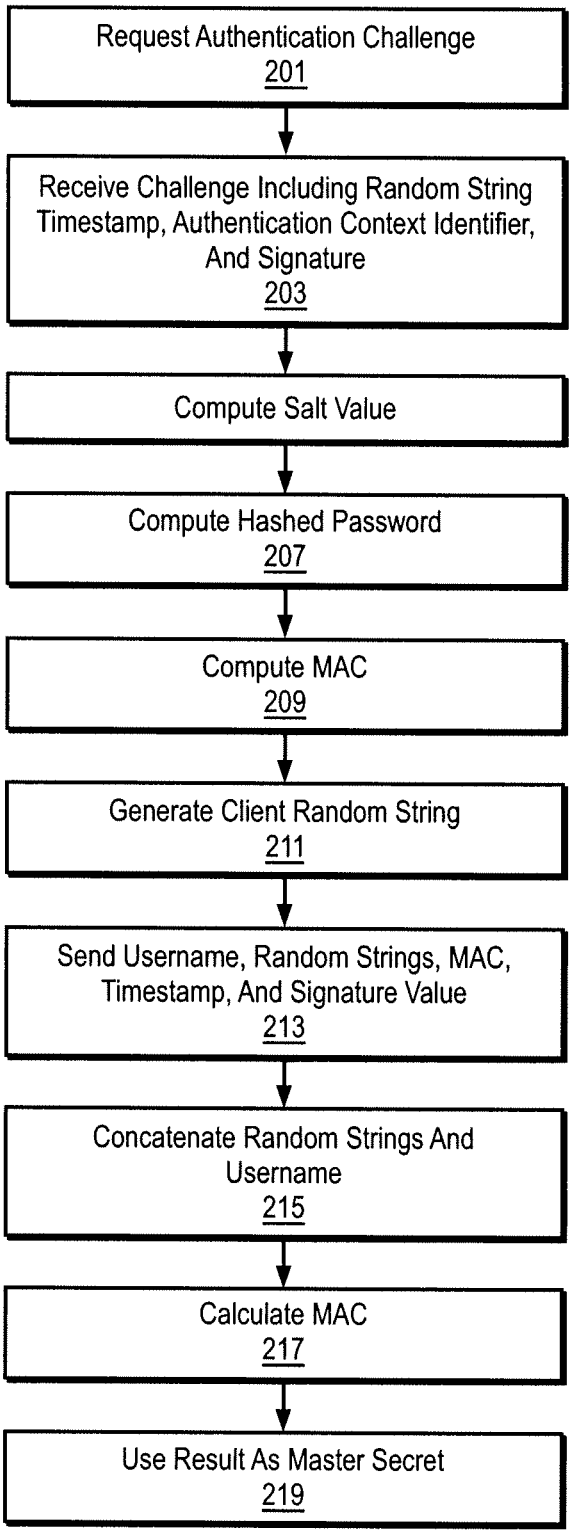

Request Authentication Challenge
201
Receive Challenge Including Random String Timestamp, Authentication Context Identifier, And Signature
203
Compute Salt Value
Compute Hashed Password
207
Compute MAC
209
Generate Client Random String
211
Send Username, Random Strings, MAC, Timestamp, And Signature Value
213
Concatenate Random Strings And Username
215
Calculate MAC
217
Use Result As Master Secret
219

FIG. 2

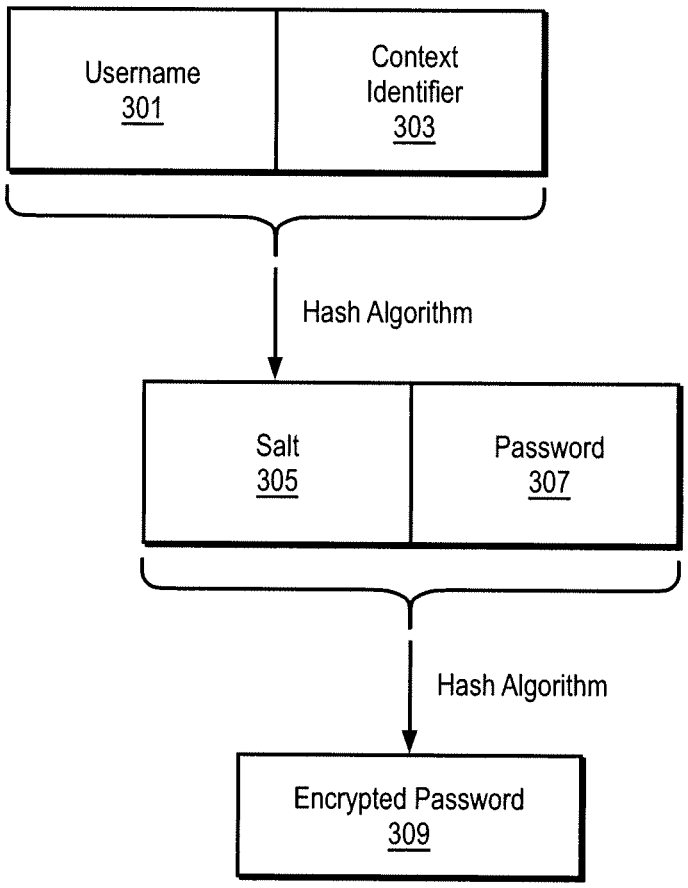

Username
301
Context
Identifier
303
Hash Algorithm
Salt
305
Password
307
Hash Algorithm
Encrypted Password
309

FIG. 3

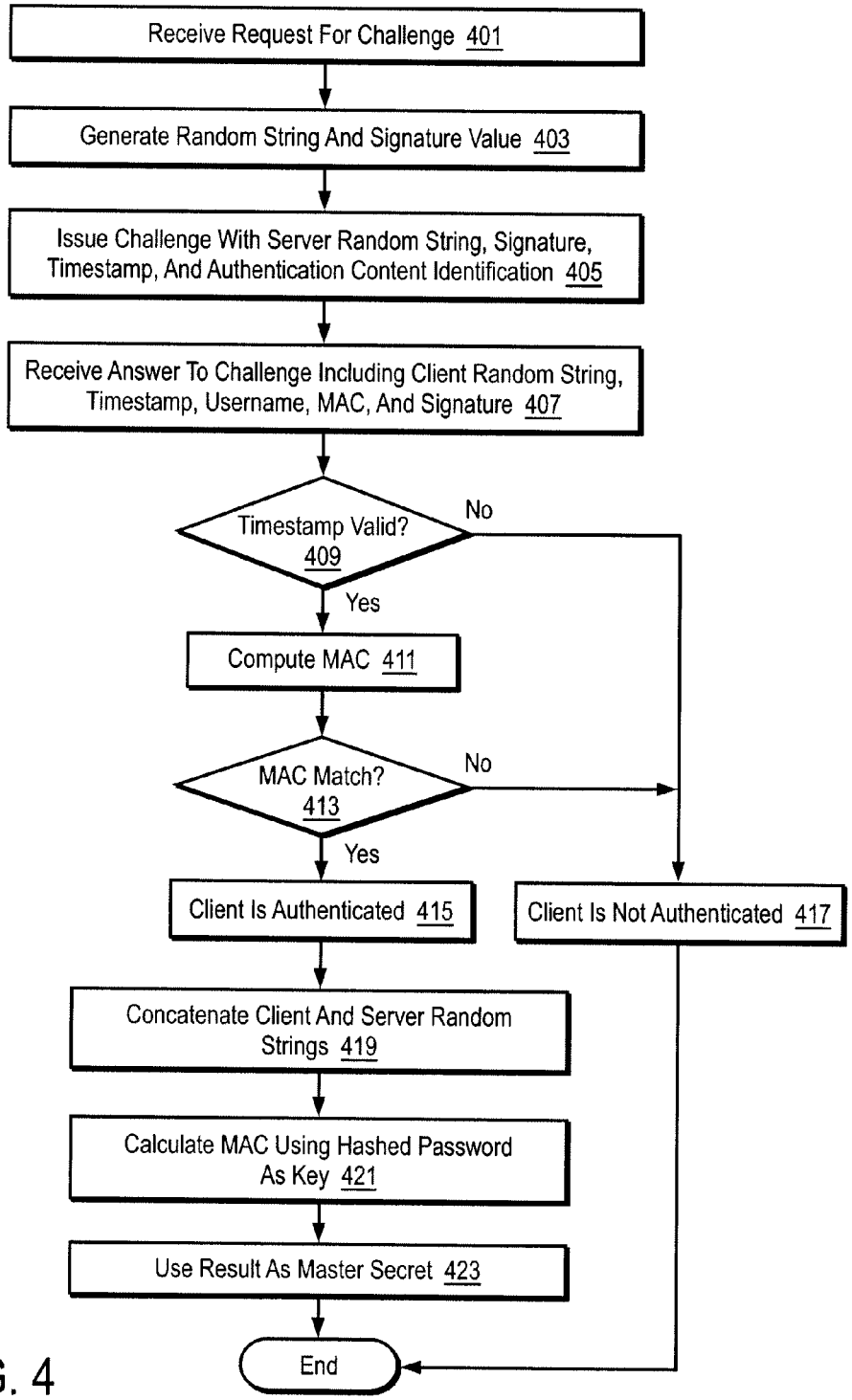

Receive Request For Challenge 401
Generate Random String And Signature Value 403
Issue Challenge With Server Random String, Signature, Timestamp, And Authentication Content Identification 405
Receive Answer To Challenge Including Client Random String, Timestamp, Username, MAC, And Signature 407
Timestamp Valid? 409
No
Yes
Compute MAC 411
MAC Match? 413
No
Yes
Client Is Authenticated 415
Client Is Not Authenticated 417
Concatenate Client And Server Random Strings 419
Calculate MAC Using Hashed Password As Key 421
Use Result As Master Secret 423
End

FIG. 4

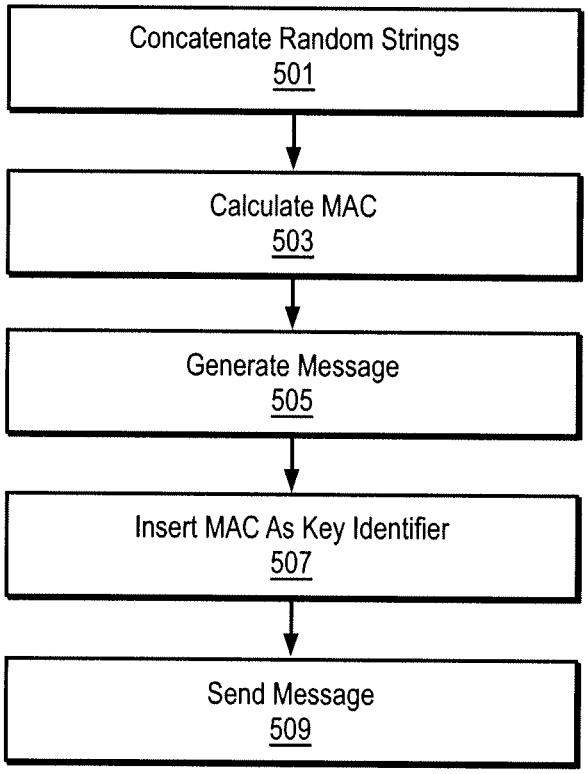

Concatenate Random Strings
501
Calculate MAC
503
Generate Message
505
Insert MAC As Key Identifier
507
Send Message
509

FIG. 5

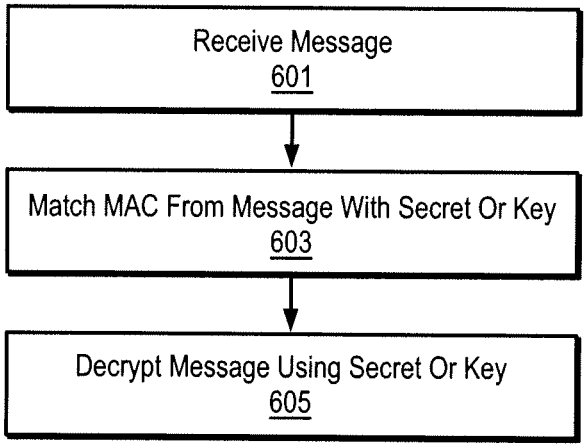

Receive Message
601
Match MAC From Message With Secret Or Key
603
Decrypt Message Using Secret Or Key
605

FIG. 6

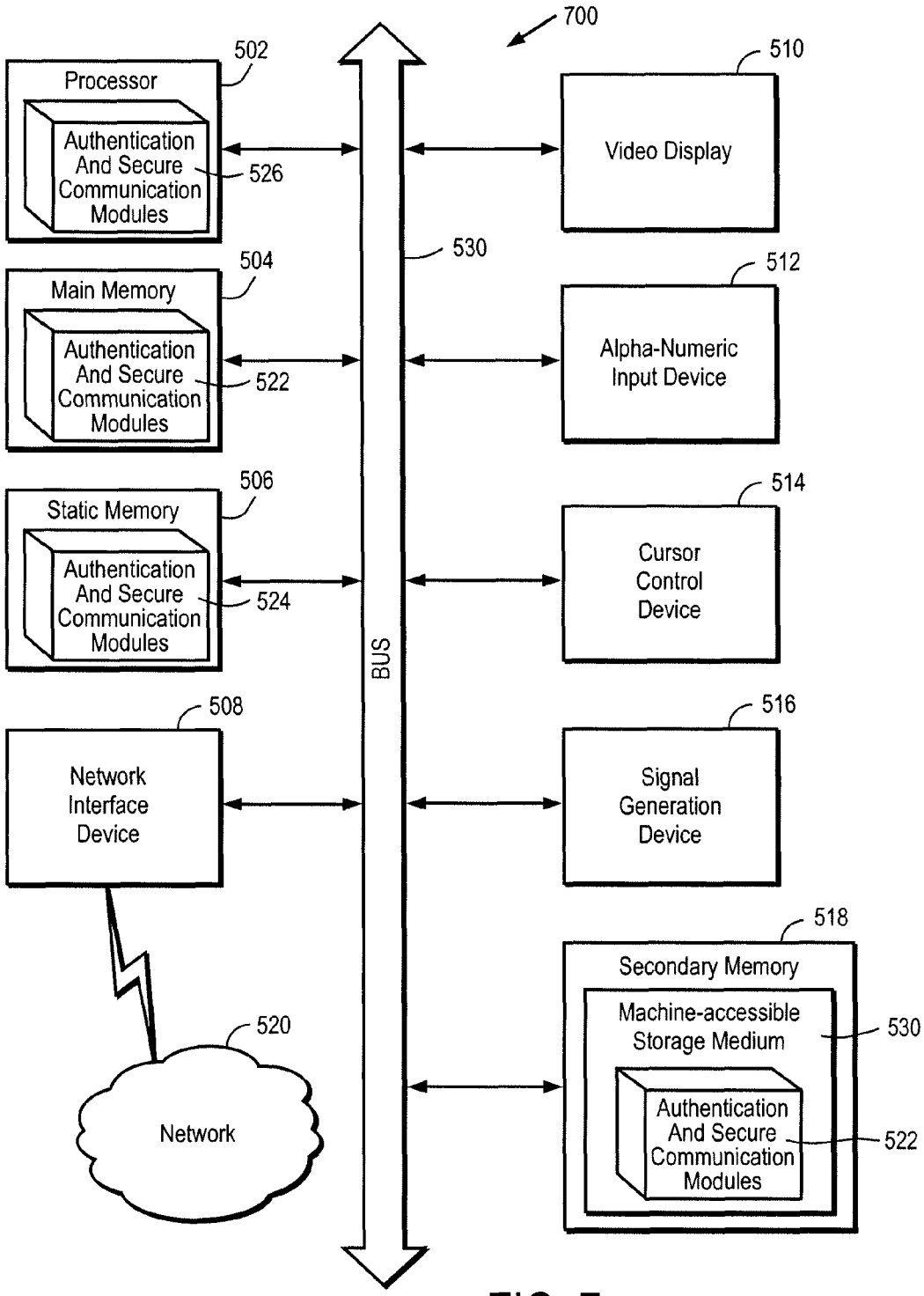

700
502
Processor
Authentication And Secure Communication Modules
526
504
Main Memory
Authentication And Secure Communication Modules
522
506
Static Memory
Authentication And Secure Communication Modules
524
508
Network Interface Device
520
Network
BUS
530
510
Video Display
512
Alpha-Numeric Input Device
514
Cursor Control Device
516
Signal Generation Device
518
Secondary Memory
Machine-accessible Storage Medium
530
Authentication And Secure Communication Modules
522

FIG. 7

USERNAME BASED KEY EXCHANGE

TECHNICAL FIELD

Embodiments of the present invention relate to secure communication system. Specifically, the embodiments of the invention relate to a method and system for securely sharing a master secret for secured communication between a server computer and client computer based on data exchanged as part of an authentication process.

BACKGROUND

One means of authentication includes the use of a password on computer systems. For example, on UNIX-type systems, the password for a user account is stored in a hashed form on the computer or at an authentication server. To make it harder for an attacker who has access to the hashed password to perform a brute force attack and potentially gain knowledge of several different systems at once, the stored password is augmented with a small random value specific to a system, also known as a "salt" before the password is hashed. The salt value and the hashed password are then stored in association with other account properties.

Since the salt value is randomly generated, only someone who already has access to the hashed password and salt value can compute what a hashed password value should be. This means that the unhashed password has to be passed to the authentication process in clear text form so that the authentication process can perform the hash and compare it to a stored hashed password. Thus, the password must only be sent over a secure connection or the password can be stolen by an eavesdropper.

Similarly, many secure communication protocols require that two communicating programs or computers have a shared secret or a shared master secret, which is either directly or indirectly utilized to encrypt data between the two communicating programs or computers. The secure communication protocols can only decrypt messages where the shared secret is known. The shared secret cannot be provided to each communicating program or computer in the clear or an eavesdropper would be able to intercept the shared secret and use it to decrypt the communications between the programs or computers.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that different references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

FIG. **1** is a block diagram illustrating one embodiment of a username based key exchange system.

FIG. **2** is a flowchart of one embodiment of a process of a client computer for authentication and shared secret exchange over an unsecured channel.

FIG. **3** is a block diagram illustrating one embodiment of a process for encrypting a password.

FIG. **4** is a flowchart of one embodiment of a process of a server for authentication and shared secret exchange over an unsecured channel.

FIG. **5** is a flowchart of one embodiment of a stateless message generation process.

FIG. **6** is a flowchart of one embodiment of a stateless message decryption process.

FIG. **7** is a diagram illustrating one embodiment of a username based key exchange system.

DETAILED DESCRIPTION

Described herein is a method and apparatus for a system and process for exchanging a secret over an unsecured channel in conjunction with an authentication system and process. In one embodiment, a client requests an authentication challenge from a server. The server generates the authentication challenge and sends it to the client. The authentication challenge includes an authentication context identifier, a first random string, a timestamp, and a signature value. The client computes a salt value based on a username and the authentication context identifier from the authentication challenge. The signature value is computed based on the authentication context identifier, the first random string, and the timestamp. The client computes a hashed password value based on the computed salt value and a message authentication code based on the hashed password value and the first random string. The client also generates a second random string. The client sends a response to the server. The response includes the username, the message authentication code, the second random string, the timestamp, and the signature value. Both the client and server concatenate the first random string, second random string and username. The concatenated value is then used to generate a media authentication code using the hashed password as a key. The resulting value is then used as a shared master secret to generate shared secrets or keys to establish a secured communication channel between the client and server. The secured communication can be based on stateless messaging where the decryption key associated with the message is identified by the message authentication code, which is placed within the message.

FIG. **1** is a block diagram illustrating one embodiment of a username based key exchange system. The system includes a client **101** that is establishing communication and authenticating with a server **131**. The client **101** can be any type of computer device including a desktop computer, laptop computer, handheld computer, console device or similar computing device. Similarly, the server **131** can be any type of computer device including a desktop computer, laptop computer, handheld computer, console device or similar computing device. The client computer **101** and server **131** can communicate over a network **111**. The network **111** can be a wide area network (WAN), such as the Internet, a local area network (LAN) or similar network. The network **111** can include any number of computers and network devices. The network **111** can include any combination of wired and wireless communication lines and devices.

In one embodiment, the client **101** includes an authentication module **103**, secure communication module **115**, stateless communication protocol module **123**, session based communication protocol module **125** and similar components. The client **101** can execute any number of applications or other programs that can interact with or utilize these components. For sake of clarity, these applications and programs are omitted from the illustration and discussion. One of ordinary skill in the art would understand that applications and programs would be inter-operable with the described aspects of the embodiments of the invention.

An authentication module **103** communicates with a server **131** to authenticate a user of the client **101** with the server **131** to obtain access to the resources managed by the server **131**. The authentication module **103** can include an encrypted password calculation module **105**, a message authentication

code (MAC) module **107**, a salt calculation module **109**, a random string generation module **113** and similar modules.

An encrypted password calculation module **105** encrypts a password received from a user of the client **101**. The encrypted password calculation module **105** generates the encrypted password as described herein below in regard to FIG. **3**. The MAC module **107** generates a MAC based on a given input and designated key. The MAC module **107** is utilized to encrypt values such as the password, a concatenation of the random strings and username and similar values. The encrypted password or any other designated value can be utilized as a key for the MAC module **107**. In another embodiment, other encryption algorithms or methods of enciphering values can be utilized in place of the MAC algorithm. The calculation of MAC values is discussed herein below in regard to FIGS. **2-4**.

A salt calculation module **109** generates a salt value. A salt value can be calculated by concatenation of a username with a context identifier or similar values. A salt value can also be generated using other methods of combining these values including hashing, encrypting, enciphering or similar algorithms. The context identifier is a value generated by a server **131** or similar system to identify the system. Using the context identifier links the encryption of the password to the particular system and prevents a compromised password on one system from compromising other systems.

A random string generation module **113** creates a random string of any given length. The random strings generated by the module **113** contribute to the security of the authentication and secured channel by preventing the server from biasing the encryption of the encrypted password and MAC values that rely on the random string, such that the encryption of these values is weakened. The random strings generated by the client and server random string generator modules **113** and **141**, together, prevent both the server and client from biasing the master key.

A secure communication module **115** interacts with the authentication module **103** utilizing the encrypted password and random strings from the authentication process to generate a shared master secret between the client **101** and the server **131**. The shared master secret can then be used as a shared secret or key or used to create shared secrets and keys for encryption algorithms that can be used to secure a channel between the two. For example, communication protocols that can utilize the shared secret or derived keys or secrets include secure sockets layer (SSL), transport secure layer (TSL) and similar protocols. The secure communication module **115** can include a master secret generator module **117**, a key generator module **119** and a stateless identifier module **121**. The master secret generator module **117** generates a master secret based on the authentication data of the authentication module **103**. One embodiment of a process for generating the master secret is described in regard to FIG. **2**. The key generator **119** utilizes the master secret and can use any type of key or secret generation, encryption or enciphering algorithm to generate any type of keys or secrets needed for use with any secure communication protocol when encrypting the secured channel. The stateless identifier module **121** generates an identifier for keys or secrets associated with a stateless message with an encrypted payload such as a user datagram protocol (UDP) packet with an encrypted payload. The process of inserting the identifier is discussed in regard to FIG. **5**.

The stateless communication protocol module **123** can be any implementation of a stateless communication protocol supported by the client system **101** such as UDP or similar protocols. The session based communication protocol module **125** can be any implementation of a session based or similar communication protocol supported by the client system **101**, such as SSL or TSL.

The server **131** may include components analogous to those of the client **101** including an authentication module **133**, a secure communication module **145**, a stateless communication protocol module **153**, a session based communication protocol module **155** and similar components. The server **131** can execute any number of applications or other programs that can interact with or utilize these components. For sake of clarity, these applications and programs are omitted from the illustration and discussion. One of ordinary skill in the art would understand that applications and programs would be inter operable with the described aspects of the embodiments of the invention.

An authentication module **133** communicates with a client **101** to authenticate a user of the client **101** with the server **131** to grant access to the resources managed by the server **131**. The authentication module **133** can include a timestamp module **135**, a message authentication code (MAC) module **143**, a signature module **137**, a random string generation module **141**, a password authentication module **139** and similar modules.

A timestamp module **135** generates a timestamp based on the current system time or similar time source. The timestamp is used to ensure that authentication messages are not valid indefinitely to secure the system from attacks using old authentication message data. The signature module **137** generates a signature based on values associated with the authentication process. The signature is used to verify the response to the authentication challenge. The password authentication module **139** checks received passwords from the client **101** against a database of valid passwords **157**.

The MAC module **143** generates a MAC based on a given input and designated key. The MAC module **143** is utilized to encrypt values such as the password, a concatenation of the random strings and username, and similar values. The encrypted password or any other designated value can be utilized as a key for the MAC module **143**. In another embodiment, other encryption algorithms or methods of enciphering values can be utilized in place of the MAC algorithm. The calculation of MAC values is discussed herein below in regard to FIGS. **2-4**.

A random string generation module **141** creates a random string of any given length. The random strings generated by the module **141** contribute to the security of the authentication and secured channel by preventing the client from biasing the encryption of the encrypted password and MAC values that rely on the random string, such that the encryption of these values is weakened. The random strings generated by the client and server random string generator modules **113** and **141**, together prevent both the server and client from biasing the master key.

A secure communication module **145** interacts with the authentication module **133** utilizing the encrypted password and random strings from the authentication process to generate a shared master secret between the client **101** and the server **131**. The shared master secret can then be used as a shared secret or key or used to create shared secrets and keys for encryption algorithms that can be used to secure a channel between the two. For example, communication protocols that can utilize the shared secret or derived keys or secrets include SSL, TSL and similar protocols. The secure communication module **145** can include a master secret generator module **149**, a key generator module **147** and a stateless identifier module **151**. The master secret generator module **149** generates a master secret based on the authentication data of the

authentication module **133**. One embodiment of a process for generating the master secret is described in regard to FIG. **4**. The key generator **147** utilizes the master secret and can use any type of key generation, encryption or enciphering algorithm to generate any type of keys for use in encryption for the secured channel. The stateless identifier module **151** generates an identifier for keys associated with a stateless message with an encrypted payload such as a UDP packet with an encrypted payload. The process of matching the identifier to a key is discussed in regard to FIG. **6**.

The stateless communication protocol module **153** can be any implementation of a stateless communication protocol supported by the server system **133** such as UDP or similar protocols. The session based communication protocol module **155** can be any implementation of a session based or similar communication protocol supported by the server system **155**, such as SSL or TSL.

FIG. **2** is a flowchart of one embodiment of a process of a client computer for authentication and shared secret exchange over an unsecured channel. In one embodiment, the process begins with a client request for an authentication challenge from a server (block **201**). Any communication or messaging protocol or system can be used to issue the request. In response, the authentication challenge is received from the server (block **203**). The request and challenge can be messages with any format or structure. The challenge includes a random string value, timestamp, signature value, authentication context identifier and similar data. The signature value is computed based on the authentication context identifier, the random string, and the timestamp. A salt value is computed based on a username associated with a user making the authentication request and the received authentication context identifier (block **205**). The computation can be a concatenation, hashing, encryption or similar algorithm.

A hashed password value is then computed based on the computed salt value and the password received from the user (block **207**). Any hashing, encryption, enciphering or similar algorithm can be used to generate a hashed or encrypted password value. A MAC can then be computed based on the hashed password value and the received random string (block **209**). In another embodiment, the client calculates a MAC over the random challenge, where the random challenge also includes the timestamp. The client generates a random string to be included in the response for use in establishing a secure communication channel (block **211**). The client returns a response to the server (block **213**). In one embodiment, the response includes the username, the MAC, the received random string, the generated randoms string, the timestamp, and the signature value.

The client then concatenates or similarly combines the two random strings (block **215**). In another embodiment, any values known to both the client and the server can be combined with or substituted for these values. A MAC of the concatenated value is then generated using the hashed password or similar value known to both the client and server as the key (block **217**). The resulting MAC is then utilized as the shared master secret for establishing a secured channel using a secure transportation protocol (block **219**).

FIG. **3** is a block diagram illustrating one embodiment of a process for encrypting a password. Instead of using a random value for a salt, a username may be used as a basis for the salt value. In that way, the client is able to calculate the hashed password value. So that the same password can be used on multiple different systems, the username can be augmented with a system-specific authentication context identifier (e.g. a random string that each authentication system uses to distinguish itself). A salt value **305** can be calculated by concatenating a context identifier **303** and a username **301**, and taking the cryptographic hash of the result. Alternately, the context identifier **303** can be used as the key in a MAC over the username **301**. An encrypted password **309** can be hashed by concatenating the calculated salt value **305** and a password **307**, then hashing the result, or by using the salt value **305** as the key in a MAC construction (or, alternately, using the password as the key, and the salt as the "message").

FIG. **4** is a flowchart of one embodiment of a process of a server for authentication and shared secret exchange over an unsecured channel. The process can be initiated when a server receives a request for an authentication challenge from a client for a given username (block **401**). The server generates a random string, an authentication context identifier, a timestamp, and a signature value (block **403**). The authentication challenge includes the username, the authentication context identifier, the random string, the timestamp, and the signature value. The signature value is computed based on the authentication context identifier, the random string and the timestamp.

The server sends the authentication challenge to the client (block **405**). The server receives a response to the authentication challenge from the client (block **407**). The response includes data based on a salt value, the salt value being based on a username and an authentication context identifier. The response includes a client generated random string, the timestamp or a client generated timestamp, the username, client generated MAC and the signature.

The server verifies the validity of the timestamp and the signature value (block **409**). The server retrieves a hashed password associated with the username provided in the response and computes a server MAC based on the random string and the retrieved hashed password (block **411**). The server compares the server MAC with the client MAC to authenticate the client (block **413**). If the timestamp is found to be not valid or if the server MAC and the client MAC do not match, the client is not authenticated (block **417**).

If the MAC values do match and the timestamp is valid, i.e., the timestamp has not exceeded a given threshold, then the client random string and the server random string are concatenated (block **419**). In another embodiment, any data known to both the client and the server can be combined with or used in combination with random string data. A MAC is calculated using the concatenated random string values as input and the received hashed or encrypted password as a key (block **421**). Other values known to the client and server can also be used in place of the password. The resulting MAC value is used as a shared master secret for establishing a secured channel using a secure transportation protocol (block **423**).

FIG. **5** is a flowchart of one embodiment of a stateless message generation process. The shared master secret can also be used for secure communication using stateless messaging. Generally, the shared master secrete is used to generate a set of shared secrets or keys for encrypting data in the stateless messages. The messages also include an identifier of the shared master secret, shared secret or key that is to be used to decrypt their payloads. In one example embodiment, the identifier is generated by first concatenating the random strings from the client and server or similarly combining these values or similar values known to both the client and the server (block **501**). A MAC is then calculated over this concatenated or combined value using the username or similar value as a key (block **503**). The message is then generated according to the stateless communication protocol (block **505**) including the insertion of the calculated MAC that serves to identify the appropriate secret or key used to encrypt the payload (block **507**). The generated message also includes

a payload encrypted using the secret or key associated with the MAC or similar value. The message is then sent to the server or client. This process can be executed by either a client or a server sending the message.

FIG. **6** is a flowchart of one embodiment of a stateless message decryption process. The receiving client or server receives the message (block **601**). The MAC of the message is then retrieved from the message. The retrieved MAC is matched with a shared secret or key by comparison with a stored set of established secrets or keys that are associated with MAC values that were derived from the combination of client and server random strings using the username as the key of the MAC. The message payload is then decrypted using the appropriate decryption algorithm and the identified secret or key.

FIG. **7** is a diagram illustrating one embodiment of a username based key exchange system. Within the computer system **700** is a set of instructions for causing the machine to perform any one or more of the methodologies discussed herein. In alternative embodiments, the machine may be connected (e.g., networked) to other machines in a LAN, an intranet, an extranet, or the Internet. The machine may operate in the capacity of a server or a client machine (e.g., a client computer executing the secure communication module and the server computer executing a secure communication module) in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The machine may be a personal computer (PC), a tablet PC, a console device or set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web appliance, a server, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines (e.g., computers) that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

The exemplary computer system **700** includes a processor **702**, a main memory **704** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM) or Rambus DRAM (RDRAM), etc.), a static memory **706** (e.g., flash memory, static random access memory (SRAM), etc.), and a secondary memory **716** (e.g., a data storage device in the form of a drive unit, which may include fixed or removable computer-readable medium), which communicate with each other via a bus **708**.

Processor **702** represents one or more general-purpose processing devices such as a microprocessor, central processing unit, or the like. More particularly, the processor **702** may be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, processor implementing other instruction sets, or processors implementing a combination of instruction sets. Processor **702** may also be one or more special-purpose processing devices such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. Processor **702** is configured to execute the desktop manager **726** for performing the operations and steps discussed herein.

The computer system **700** may further include a network interface device **722**. The computer system **700** also may include a video display unit **710** (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)) connected to the computer system through a graphics port and graphics chipset, an alphanumeric input device **712** (e.g., a keyboard), a cursor control device **714** (e.g., a mouse), and a signal generation device **720** (e.g., a speaker).

The secondary memory **716** may include a machine-readable storage medium (or more specifically a computer-readable storage medium) **724** on which is stored one or more sets of instructions (e.g., the authentication module and secure communication module **726**) embodying any one or more of the methodologies or functions described herein. The authentication module and secure communication module **726** may also reside, completely or at least partially, within the main memory **704** and/or within the processing device **702** during execution thereof by the computer system **700**, the main memory **704** and the processing device **702** also constituting machine-readable storage media. The authentication module and secure communication module **726** may further be transmitted or received over a network **718** via the network interface device **722**.

The machine-readable storage medium **724** may also be used to store the authentication module and secure communication module **726** persistently. While the machine-readable storage medium **726** is shown in an exemplary embodiment to be a single medium, the term "machine-readable storage medium" and also "computer-readable medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The terms "machine-readable storage medium" and "computer-readable medium" shall also be taken to include any medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention. The terms "machine-readable storage medium" and "computer-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media.

In the above description, numerous details are set forth. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form, rather than in detail, in order to avoid obscuring the present invention.

Some portions of the detailed descriptions above are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the above discussion, it is appreciated that throughout the description, discussions utilizing terms such as "sending," "generating," "receiving," "authenticating," "concatenating," "calculating," "inserting" or the like, refer to the actions and processes of a computer system, or similar

electronic computing device that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories, registers or other such information storage, transmission or display devices.

The present invention also relates to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes or it may comprise a general purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but not limited to, any type of disk including floppy disks, optical disks, CD-ROMs and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, Flash memory devices including universal serial bus (USB) storage devices (e.g., USB key devices) or any type of media suitable for storing electronic instructions, each of which may be coupled to a computer system bus.

The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose systems may be used with programs in accordance with the teachings herein or it may prove convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these systems will appear from the description below. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein.

A computer readable medium includes any mechanism for storing information in a form readable by a computer. For example, a computer readable medium includes read only memory ("ROM"), random access memory ("RAM"), magnetic disk storage media; optical storage media, flash memory devices or other type of machine-accessible storage media.

Thus, a method and apparatus for username based key exchange has been described. It is to be understood that the above description is intended to be illustrative and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reading and understanding the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

What is claimed is:

1. A method comprising:

sending, by a processor over a network, a first random string in response to a request from a device;

receiving, by the processor over the network, a second random string and a username from the device in response to the first random string;

concatenating, by the processor, the first random string, the second random string and the username to form a first value;

generating, by the processor, a first secret using the first value as input to a cryptographic function and a hashed password associated with the username as a cryptographic key; and

establishing, by the processor, a communication session with the device over the network using a second secret derived from the first secret.

2. The method of claim **1**, further comprising:

generating the second secret from the first secret for use in a secure communication protocol for the communication session.

3. The method of claim **1**, further comprising:

calculating a first message authentication code in view of the second secret.

4. The method of claim **3**, further comprising:

inserting a second message authentication code into a message as a decryption key identifier.

5. A non-transitory computer-readable medium comprising instructions encoded thereon which, when executed by a processor, cause the processor to:

send, by the processor over a network, a first random string in response to a request from a device;

receive, by the processor over the network, a second random string and a username in response to the first random string;

concatenate, by the processor, the first random string, the second random string and the username to form a first value;

generate, by the processor, a first secret using the first value as input to a cryptographic function and a hashed password associated with the username as a cryptographic key; and

establish, by the processor, a communication session with the device over the network using a second secret derived from the first secret.

6. The non-transitory computer-readable medium of claim **5**, wherein the processor further to:

generate the second secret from the first secret for use in a secure communication protocol for the communication session.

7. The non-transitory computer-readable medium of claim **6**, wherein the processor further to:

insert a second message authentication code into a message as a decryption key identifier.

8. A method comprising:

receiving, by a processor over a network, a first random string from a device;

sending, by the processor over the network, a second random string and a username in response to the first random string; and

concatenating, by the processor, the first random string, the second random string and the username to form a first value;

generating, by the processor, a first secret using the first value as input to a cryptographic function and a hashed password associated with the username as a cryptographic key; and

establishing, by the processor, a communication session with the device over the network using a second secret derived from the first secret.

9. The method of claim **8**, further comprising:

generating the second secret from the first secret for use in a secure communication protocol for the communication session.

10. The method of claim **8**, further comprising:

calculating a first message authentication code in view of the second secret.

11. The method of claim **10**, further comprising:

inserting a second message authentication code into a message as a decryption key identifier.

12. A non-transitory computer-readable medium comprising instructions encoded thereon which, when executed by a processor, cause the processor to:

receive, by the processor over a network, a first random string from a device;

send, by the processor over the network, a second random string and a username in response to the first random string;

concatenate, by the processor, the first random string, the second random string and the username to form a first value;

generate, by the processor, a first secret using the first value as input to a cryptographic function and a hashed password associated with the username as a cryptographic key; and

establish, by the processor, a communication session with the device over the network using a second secret derived from the first secret.

13. The non-transitory computer-readable medium of claim **12**, wherein the processor further to:

generate the second secret from the first secret for use in a secure communication protocol for the communication session.

14. The non-transitory computer-readable medium of claim **13**, wherein the processor further to:

calculate a first message authentication code in view of the second secret.

15. The non-transitory computer-readable medium of claim **14**, wherein the processor further to:

insert a second message authentication code into a message as a decryption key identifier.

16. A system comprising:

a memory;

a network interface device; and

a processor operatively coupled to the memory, the processor to:

send, over a network using the network interface device, a first random string in response to a request from a device;

receive, over the network using the network interface device, a second random string and a username in response to the first random string;

concatenate the first random string, the second random string and the username to form a first value;

generate a first secret using the first value as input to a cryptographic function and a hashed password associated with the username as a cryptographic key; and

establish a communication session with the device over the network using a second secret derived from the first secret.

17. The system of claim **16**, wherein the processor is further to:

generate the second secret from the first secret for use in a secure communication protocol for the communication session.

18. The method of claim **1**, wherein the network is at least one of a wide area network (WAN) or a local area network (LAN).

19. The method of claim **1**, wherein sending the first random string in response to a request comprises sending the first random string by a server device over the network in response to the request from a client device.

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